Practice

Quality improvement report

Reducing dialysis associated bacteraemia, and recommendations for surveillance in the United Kingdom: prospective study

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Abstract

Problem Bacteraemia in dialysis units accounts for major morbidity, mortality, and antibiotic usage. Risk is much greater when lines rather than fistulas are used for haemodialysis. Surveillance is critical for infection control, but no standardised surveillance scheme exists in the United Kingdom.
Design Prospective study in a London dialysis unit of the implementation and applicability of a dialysis associated bacteraemia surveillance scheme developed in the United States and its effect on bacteraemia, antibiotic usage, and admission.
Setting Hammersmith Hospital dialysis unit, London, where 112 outpatients receive dialysis three times weekly. Between June 2002 and December 2004, 3418 patient months of data were collected.
Key measures for improvement Successful adoption of the scheme and reductions in bacteraemia rates, antibiotic usage, and admission to hospital.
Strategy for improvement Embedding the surveillance scheme in the unit's clinical activity.
Effects of change Raised awareness of bacteraemia prevention, prudent antibiotic prescribing, and the need for improved provision of vascular access. The scheme required two hours a month of consultant time. Significant downward trends were seen in bacteraemia rates and antibiotic usage: mean rate ratios from quarter to quarter 0.90 (95% confidence interval 0.85 to 0.94) and 0.91 (0.87 to 0.96), respectively. The rate of admission to hospital also showed a significant downward trend, with admissions directly connected to access related infection declining more rapidly: mean rate ratio of successive quarters 0.90 (0.84 to 0.96). The overall proportion of patients dialysed through catheters was significantly higher than in US outpatient centres (62.3% v 29.4%, P < 0.01). Study data were successfully used in a business case to improve access provision.
Lessons learnt Dialysis specific surveillance of bacteraemia is critical to infection control in dialysis units and improving quality of care. Such a scheme could be adopted across the United Kingdom.

Outline of problem

Although major morbidity and mortality are associated with dialysis related bacteraemia, no standardised national surveillance scheme exists in the United Kingdom.[1] Surveillance is the key to infection control and prevention, risk management, and quality improvement.

A major risk factor for bacteraemia is the mode of vascular access for haemodialysis. Appropriate access must be established before haemodialysis can start. Haemodialysis catheters are easy to place into central veins, providing immediate circulatory access. Both non-cuffed temporary catheters and cuffed long term tunnelled catheters are used (fig 1). For patients who require long term haemodialysis the optimal choice is the formation of a native arteriovenous fistula (fig 2); when this is not surgically possible, a prosthetic graft can be created. Those patients requiring haemodialysis before an arteriovenous fistula or graft can be established (they take several weeks to mature) can be dialysed through either type of catheter. However, catheters remain widely used as the long term mode of vascular access in patients requiring long term haemodialysis.

Data from 20 months of surveillance in the United States showed that the risk of bacteraemia was 32 times greater when haemodialysis was through a non-cuffed temporary catheter than through an arteriovenous fistula and 19 times greater when through a tunnelled, cuffed catheter.[2] A similar hierarchy of risk was seen in a six month study of 11 centres in Canada.[3] The dialysis outcomes and practice pattern study showed that the arteriovenous fistula is the most desirable mode of vascular access for haemodialysis, producing highest flows, minimising sepsis, and having the longest survival. The reported proportion of arteriovenous fistulas among patients requiring haemodialysis varies widely—for example, 90% in Italy and 67% in the United Kingdom—as a result of differing availability of access surgery

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Key learning points

Patients receiving haemodialysis have a high risk of bacteraemia; the risk is greatest if vascular catheters rather than arteriovenous fistulas are used for access

Surveillance is key to an infection prevention programme and improving the quality of care

A specific bacteraemia surveillance scheme is required for this population that uses appropriate denominator data, recognises the mode of vascular access, and can standardise rates accordingly

For successful implementation, surveillance should fully involve the clinical staff and be embedded in routine daily practice, with simple event driven data collection

Such a scheme was adopted in a busy London unit, with reductions in bacteraemia, admissions, and antibiotic usage, but national benchmarking will require its adoption in other NHS units and a coordinated national strategy

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Fig 1 Cuffed tunnelled catheter

and assessments before dialysis.[4] Data from the 2004 dialysis outcomes and practice pattern study showed that in Europe the United Kingdom had the highest absolute rate of admissions to hospital secondary to infection related to vascular access, which varied from 0.01 per patient year in Italy to 0.08 in the United Kingdom.[5]

Tunnelled, cuffed catheters are preferable to non-cuffed temporary catheters owing to the lower rate of bacteraemia.[2 6] They can still lead to various complications, however: not only infective complications (bacteraemia leading to endocarditis and metastatic infections) but mechanical complications too (catheter malfunction and central vein thrombosis preventing subsequent formation of an arteriovenous fistula in that limb). Patient comorbidity also affects risk—for example, the incidence of bacteraemia is greater in patients with diabetes.[7–9]

The five year survival rate for a patient receiving haemodialysis is 34%.[10] Infection is the second most common cause of death, after cardiovascular events.[7 10] The mode of access affects mortality, with arteriovenous fistulas carrying the least risk and temporary catheters carrying the greatest.[9–11] Long term use of catheters can also compromise the longevity of haemodialysis. Infections can result in the removal and placement of catheters

Fig 2 Arteriovenous fistula

at different sites. This can traumatise central veins, leading to scarring, stenosis, and thrombosis, which potentially jeopardises future fistula creation peripherally and the opportunity for successful transplantation. Over reliance on catheters can lead to failure of haemodialysis within a few years owing to loss of vascular access. The situation is compounded in the United Kingdom by the scarce supply of cadaver transplant organs, which forces patients to continue with dialysis for longer. This is a particular problem for some ethnic minorities in the United Kingdom, who have greater need for renal replacement therapy[12] secondary to diabetes and cardiovascular disease and whose blood group characteristics are not commonly matched by the donor population.[13 14]

In addition to the risk of bacteraemia associated with mode of access and patient risk factors, other important risks need to be considered. These include standards of line care, infection control practice, water quality,[15] staff training, and staffing levels.[16] Surveillance data on bacteraemia in dialysis units would reflect all these factors and target action.

Current status of surveillance of dialysis bacteraemia

Surveillance is a critical component of infection control yet no specific scheme, with appropriate denominator data and risk stratification, for dialysis associated bacteraemia exists in the United Kingdom.[1] In 2004 the UK National Audit Office report on nosocomial infection stated that surveillance was patchy. The report identified renal units as an area that particularly required surveillance schemes.[1] Dialysis units were not previously covered in the nosocomial infection national surveillance scheme run by the Public Health Laboratory Service, as only inpatients were included. Furthermore, participation in the surveillance scheme was largely managed by infection control teams and not embedded in the clinical services. The national mandatory methicillin resistant *Staphylococcus aureus* bacteraemia surveillance[17] is inadequate for patients receiving dialysis because of the lack of appropriate denominator data and the breadth of isolates causing bacteraemia. Neither the UK Renal Association Standards and Audits Group[15] nor the UK Renal National Service Framework[18] recommends schemes or targets for dialysis associated bacteraemia.

In 1999 the US Centers for Disease Control and Prevention in Atlanta established the Dialysis Surveillance Network, a voluntary system to monitor bloodstream and vascular infections across outpatient dialysis units in the United States. Data from different units can be appropriately compared as it takes into account access provision. The network is now well established.[2] By the end of our study period the network had 325 378 patient months of data from the participating units.

The local context

On average the Hammersmith in-centre dialysis unit dialyses 112 patients (1344 dialysis episodes) a month. Predominantly it provides for patients starting dialysis and those with major comorbidities that prevent them from dialysing in a satellite unit. Many of the patients were unsuited to the formation of an ateriovenous fistula or had failed previous access. Availability of access surgery was limited. Seventy four per cent of the patients therefore had tunnelled catheters. The unit had a high rate of hospital admissions due to access problems. Water quality met national standards.[14]

Key measures for improvement

Our key improvement measure was the embedding of a dialysis specific bacteraemia surveillance scheme in the local unit's

activities. We used compliance with surveillance and capture of data as a measure of success in the implementation of this scheme. Reductions in bacteraemia rates, admissions to hospital, and antibiotic usage were measures of the scheme's effect.

Strategy for local improvement

Collaboration was established with the Centers for Disease Control in April 2002 to pilot the Dialysis Surveillance Network scheme in London. We aimed to assess the bacteraemia rate in our unit and improve quality of care, to study the local effect of the surveillance programme, and to assess if the scheme could be adopted by a busy London centre and have applicability for dialysis units in the United Kingdom.

Data gathering and analysis

A simple, user friendly form was filled in whenever a patient was admitted to hospital or started intravenous antibiotics. We then recorded the type of vascular access and whether it was removed, the presence or absence of criteria for infections, and blood culture results. The denominator was provided by a simple census form of type of vascular access for all patients dialysed in the first week of each surveillance month.[2] At the end of the month we reviewed the data, which were counterchecked by the lead clinician and nurse. The Dialysis Surveillance Network received our anonymised data monthly for analysis. The network's computer algorithm determined if case definitions for infection were met.[2] Access related bacteraemia was defined as a positive blood culture in the presence of clinical signs of infection, with the patient started on intravenous antibiotics or admitted to hospital, and the suspected source of the positive blood culture being the vascular access or uncertain. The algorithm reported the frequency of obtaining blood cultures, starting antimicrobials, bacteraemia, and admission to hospital. Rates were expressed both as crude rates and after standardisation for access type, and also compared with all participating US outpatient units. We calculated the total number of patient months by adding up the census during the first week of each month of data collection. We expressed rates of events per 100 patient months, calculated by dividing the total number of events by the total number of patient months and multiplying the result by 100. The rate ratios were calculated by dividing the rate in one centre (London centre) by the rate in the baseline group (pooled US centres). We used the exact binomial method to calculate the 95% confidence intervals for rate ratios and the binomial or Poisson distribution to calculate exact P values. Indirect standardisation was used to calculate the rate ratios standardised for mix of vascular access types. P values were two tailed.[2]

In total 31 months of surveillance took place, equivalent to 3418 patient months of data. Data included a total of 523 incidents (404 admissions to hospital and 239 prescriptions of intravenous antibiotics initiated) and 172 episodes of access related bacteraemia.

Effects of change

After the initial set up of surveillance, the scheme required two hours a month of a consultant's time. The dialysis unit staff considered that continuous rather than intermittent surveillance was more efficient, and embedded the scheme in the day to day activities of the unit. This fostered local ownership and clinical engagement. Compliance was maintained throughout the study period. Surveillance raised awareness and provided a cornerstone for improved infection control and line care involving all staff of the dialysis unit. The data feedback generated unit led

programmes of risk reduction and infection control. The surveillance data were also a powerful business tool to negotiate improved resources for access provision.

Outcome measures

Access related bacteraemia

The crude rate for access related bacteraemia between June and September 2002 was 6.2 per 100 patient months. We had a significantly higher usage of catheters than the participating units in the United States (74% v 29.3%, P < 0.001). The bacteraemia rate fell to 3.2 when the bacteraemia rate was standardised for access mix (fig 3). This was still significantly higher (P < 0.01) than the overall US rate of 1.8, indicating that infection control activity around line insertion and line care could be improved. Fuelled by these data, from November 2003 we started an extensive unit based programme of risk reduction, infection prevention and control, education and awareness, and improvement of access provision. With weekly multidisciplinary meetings on infection in September and December 2004 the crude rate was 2.0 per 100 patient months (1.1 per 100 patient months when standardised for access). This represents a significant overall downward trend; the average ratios of rates in successive quarters in this 31 month period were 0.90 (95% confidence interval 0.85 to 0.94, P < 0.001; table).

Antibiotic usage

A similar trend in the incidence of starting intravenous antibiotics was found (rates fell from 7.7 per 100 patient months during June to September 2002 to 4.10 during September to December 2004; fig 3). Clinical criteria for starting antibiotics remained unchanged throughout the surveillance period. The average ratio of rates in successive quarters was 0.91 (95% confidence interval 0.87 to 0.95). The rate of starting intravenous vancomycin decreased from 6.4 during June to September 2002 to 3.6 during September to December 2004 (average ratio of successive quarters 0.91, 0.87 to 0.96, P < 0.001; table).

Access provision

The unit used a significantly higher proportion of catheters (74%) than the participating US centres (29.3%, P < 0.001). With the data from the surveillance scheme, a successful business case was made to increase access provision. The rate of formation of arteriovenous fistulas in the unit rose to 45% in December 2003.
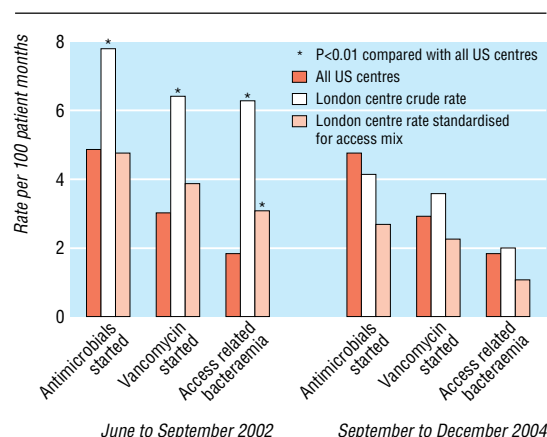

Fig 3 Rates per 100 patient months for starting intravenous antibiotics and access related bacteraemia in US centres compared with London centre at start and end of study period

Overall trends in events across 31 month continuous study period

Events	Start period June to September 2002					End period September to December 2004					Mean rate ratio (95% CI); overall trend† in rates across June 2002 to December 2004
	Rates/100 patient months	No of events by access type				Rates/100 patient months	No of events by access type				
		Fistula	Graft	Permanent catheter	Temporary catheter		Fistula	Graft	Permanent catheter	Temporary catheter	
Started intravenous antimicrobials	7.7	1	0	30	0	4.1	0	0	12	1	0.91** (0.87 to 0.95)
Started vancomycin	6.4	0	0	26	0	3.6	0	0	10	1	0.91** (0.87 to 0.96)
Access related bacteraemia	6.2	0	0	25	0	2.0	0	0	6	0	0.90** (0.85 to 0.94)
Admission to hospital due to access related infection	4.0	0	0	16	0	1.4	0	0	6	0	0.90* (0.84 to 0.96)

*P=0.001; **P<0.001.

†Trends in rates of event occurrence determined from Poisson regression of number of events in quarter (three month period) per 100 patient months, against quarter number. Trend is expressed as mean rate ratio, comparing rate in each quarter with previous quarter.

By the end of the study period, however, it fell back to 30% owing to changes in case mix and high throughput of new patients for dialysis. Despite this, the significant downward trend in bacteraemia and antibiotic usage was maintained, indicating sustained improved line care and infection control.

Rates of admission to hospital
In the first quarter the overall rate of admission to hospital was 15 per 100 patient months. By the last quarter of the study (October to December 2004) it had fallen to 12.3, representing a significant overall downward trend: average ratio of successive quarters 0.95, 0.92 to 0.99; P = 0.006). Admissions for access related infection declined more rapidly: average ratio of successive quarters 0.90, 0.84 to 0.96; P = 0.001), falling from 4.00 per 100 patient months at the beginning to 1.4 at the end (table).

Lessons learnt and next steps

We showed that a dialysis specific surveillance scheme could be easily and successfully embedded in a busy London dialysis unit. Local knowledge and ownership of data at a unit level are critical to generating change and quality improvement. After implementation of the scheme, awareness of infection control and optimising vascular access increased and rates of bacteraemia and antimicrobial usage fell significantly. The effect on antibiotic prescribing has particular public health importance, as intense antibiotic usage in dialysis units has contributed to the global emergence of antibiotic resistance.[19 20] Although the scheme had much local benefit, it was limited in facilitating useful external benchmarking. Comparison of data from an in-centre dialysis unit at a tertiary care NHS hospital with data from US outpatient dialysis units is unsatisfactory, as there are potentially many differences in care provision, practice, staffing, and case mix. However, we propose that this scheme has general applicability for UK dialysis units and should be adopted as a nationwide dialysis associated bacteraemia surveillance programme. This would tackle this important healthcare associated infection at a national level in the growing population of patients requiring dialysis in the United Kingdom. The opportunity also arises to add to the dataset to obtain further information on risk factors, practice, antibiotic usage, and antibiotic resistance.

Implementation of such a surveillance scheme for bacteraemia should be part of quality care and risk management activity for all dialysis units. This would allow useful comparisons across the United Kingdom, facilitate local monitoring and targeted action, and provide the background for practice evaluation and research.

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(Accepted 13 April 2006)

bmj.com 2006;332:1435

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